Application No. 10/043,473

#3

Applicant	:	Charles R. Cutler
Appl. No.	:	10/043,473
Filed	:	01/10/2002
Title	:	Method of removal of PID dynamics from MPC models
Group./A.U.	:	2121
Examiner	:	Unassigned
Docket No.	:	MAE-CRC-02

October 28, 2002

Honorable Commissioner for Patents
Washington DC 20231

PRELIMINARY AMENDMENT

Sir:

In response to the Formalities Letter of February 13, 2002 (Notice of Omitted Items) please amend the above-identified application as follows:

In the Specification:

Please omit paragraph [00021] on page 7.

Please replace paragraphs [00022 thru 00026] on page 7, with the following rewritten paragraphs:

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Figure 1 is a complex flow schematic of a fractionator

Figure 2 is a simulation of the fractionator model based on valve positions

Figure 3 demonstrates the results from a plant test of the fractionator

Figure 4 is a simulation of the fractionator with the PID controllers

Figure 5 is a demonstration of the fractionator with the original and recovered values

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Please replace paragraph [00029] on page 7, with the following rewritten paragraph:

-- An MPC controller is often based on a linear model of a process system. Although the invention to be described here has applications in many fields the examples used will be from chemical and refinery process applications. –

Please replace paragraph [00030] on page 7 with the following rewritten paragraph:

-- There are two types of variables in any system; the *independent variables* and the *dependent variables*. The *independent variables are inputs* to the system. The independent variables are further divided into manipulated and disturbance (feedforward) variables. Manipulated variables are those that can be changed by the human operator, such as valve positions or PID controller set points. Disturbance variables are those independent variables that have an effect on the system, but cannot be changed by the human operator. Variables such as feed composition, feed temperature, and ambient temperature are examples of disturbance variables. --

Please replace paragraph [00031] on page 8 with the following rewritten paragraph:

-- Dependent variables are outputs from the system. Dependent variables are affected by changes in the independent variables. The human operator cannot directly change them. The values of dependent variables can be controlled, however, by correctly changing the values of the manipulated variables. Further, as disturbances enter the system, the manipulated variables must be correctly adjusted to counteract the disturbance. --

Please replace paragraph [00075] on page 29 with the following rewritten paragraph:

-- The schematic for the Complex Fractionator is shown in Figure 1. The feed flow rate **5** is controlled by the upstream unit and is pre-heated in a furnace **6**. The fractionator **7** has a top, middle and bottom product. The fractionator overhead temperature is controlled with a PI controller **8** moving the top reflux. The middle product draw temperature is controlled with a PI controller **9** moving the middle product draw rate. A third PI controller **10** moves the bottom product rate to control the fractionator bottoms level. The bottom composition (light component) is measured with an analyzer **11**. --

Please replace paragraph [00083] on page 30 with the following rewritten paragraph:

-- The model coefficients are shown in Table 1 and the model plots are shown in Figure 2. This model, based on valve positions, is used to predict future system behavior in the model dependent variables based on past and present changes in the model independent variables. --

Please replace paragraph [00085] on page 33 with the following rewritten paragraph:

-- A plant test was performed (data plots in FIG. 3) with these PI controllers regulating the process. The independent and dependent variables for the system were as follows: --

Please replace paragraph [00087] on page 34 with the following rewritten paragraph:

-- The resulting data were analyzed and a model based on this PID configuration was identified, as shown in FIG. 4. --

Please replace paragraph [00088] on page 34 with the following rewritten paragraph:

-- The new algorithm to remove PID dynamics was applied to the model shown in FIG. 4, and this model with the PID dynamics removed is compared to the original simulation model. As can be seen in FIG. 5, the algorithm successfully recovers the original valve based model. Note that the steady state time of the recovered model is longer than the steady state time of the original model. This is a result of a longer steady state time for the model with the PID controllers. The original valve-based simulation model had a steady state time of 90 minutes. When the PID controllers were configured and the plant step-test performed, it took 180 minutes for the process to reach steady state, due to having to wait for the PID feedback control to settle out. The steady state time of the recovered valve-based model has the same steady state time as the model containing the PID dynamics from which it was generated. It can be seen, however, that the recovered model has reached steady state in 90 minutes, and if it were truncated at that point, would exactly match the original valve-based model. --

In the claims:

No change in the claims.

In the drawings:

Please omit Figure 1 and renumber Figure 2 through 6 to Figure 1 through 5. Copies of the original figures are attached with the figure numbers changed in red ink as requested by the Initial Patent Examination Division.

REMARKS/ARGUMENTS

Applicant respectively submits that the requested changes add no new matter and in fact only omit Figure 1 and renumber figures. Changes to the specification are made solely to address the changes in the figure numbers. No changes are made to the remaining figures and no changes to the submitted claims.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned

"Version with markings to show changes made."

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Respectfully submitted,

BY_________________________

Michael A. Ervin
Reg. No. 45,711
(512) 329-6085

Application No. 10/043,473

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the specification:

Paragraphs [00021 thru 00026] have been modified as follows:

~~Figure 1 is a schematic demonstrating dependent and independent variables~~

Figure 1 ~~2~~ is a ~~more~~ complex flow schematic of a fractionator

Figure 2 ~~3~~ is a simulation of the fractionator model based on valve positions

Figure 3 ~~4~~ demonstrates the results from a plant test of the fractionator

Figure 4 ~~5~~ is a simulation of the fractionator with the PID controllers

Figure 5 ~~6~~ is a demonstration of the fractionator with the original and recovered values

Paragraph [00029], page 7 has been amended as follows:

An MPC controller is often based on a linear model of a process system. ~~For example see Figure 1.~~ Although the invention to be described here has applications in many fields the examples used will be from chemical and refinery process applications.

Paragraph [00030], page 7 has been amended as follows:

There are two types of variables in any system; the *independent variables* and the *dependent variables.* The *independent variables are inputs* to the system. The independent variables are further divided into manipulated and disturbance (feedforward) variables. Manipulated variables are those that can be changed by the human operator, such as valve positions or PID controller set points. ~~The furnace fuel gas flow set point (1) is a manipulated independent variable.~~ Disturbance variables are those independent variables that have an effect on the system, but cannot be changed by the human operator. Variables such as feed

composition, feed temperature, and ambient temperature are examples of disturbance variables. ~~The furnace inlet temperature (2) is a disturbance variable.~~

Paragraph [00031], page 8 has been amended as follows:

Dependent variables are outputs from the system. Dependent variables are affected by changes in the independent variables. The human operator cannot directly change them. The values of dependent variables can be controlled, however, by correctly changing the values of the manipulated variables. Further, as disturbances enter the system, the manipulated variables must be correctly adjusted to counteract the disturbance. ~~The furnace outlet temperature (3) and stack temperature (4) are examples of dependent variables.~~

Paragraph [00075], page 29 has been amended as follows:

The schematic for the Complex Fractionator is shown in Figure 1 ~~2~~. The feed flow rate **5** is controlled by the upstream unit and is pre-heated in a furnace **6**. The fractionator **7** has a top, middle and bottom product. The fractionator overhead temperature is controlled with a PI controller **8** moving the top reflux. The middle product draw temperature is controlled with a PI controller **9** moving the middle product draw rate. A third PI controller **10** moves the bottom product rate to control the fractionator bottoms level. The bottom composition (light component) is measured with an analyzer **11**.

Paragraph [00083], page 30 has been amended as follows:

The model coefficients are shown in Table 1 and the model plots are shown in Figure 2 ~~3~~. This model, based on valve positions, is used to predict future

system behavior in the model dependent variables based on past and present changes in the model independent variables.

Paragraph [00085], page 33 has been amended as follows:

A plant test was performed (data plots in FIG. 3 ~~4~~) with these PI controllers regulating the process. The independent and dependent variables for the system were as follows:

Paragraph [00087], page 34 has been amended as follows:

The resulting data were analyzed and a model based on this PID configuration was identified, as shown in FIG. 4 ~~5~~.

Paragraph [00088], page 34 has been amended as follows:

The new algorithm to remove PID dynamics was applied to the model shown in FIG. 4 ~~5~~, and this model with the PID dynamics removed is compared to the original simulation model. As can be seen in FIG. 5 ~~6~~, the algorithm successfully recovers the original valve based model. Note that the steady state time of the recovered model is longer than the steady state time of the original model. This is a result of a longer steady state time for the model with the PID controllers. The original valve-based simulation model had a steady state time of 90 minutes. When the PID controllers were configured and the plant step-test performed, it took 180 minutes for the process to reach steady state, due to having to wait for the PID feedback control to settle out. The steady state time of the recovered valve-based model has the same steady state time as the model containing the PID dynamics from which it was generated. It can be seen, however, that the

recovered model has reached steady state in 90 minutes, and if it were truncated at that point, would exactly match the original valve-based model.

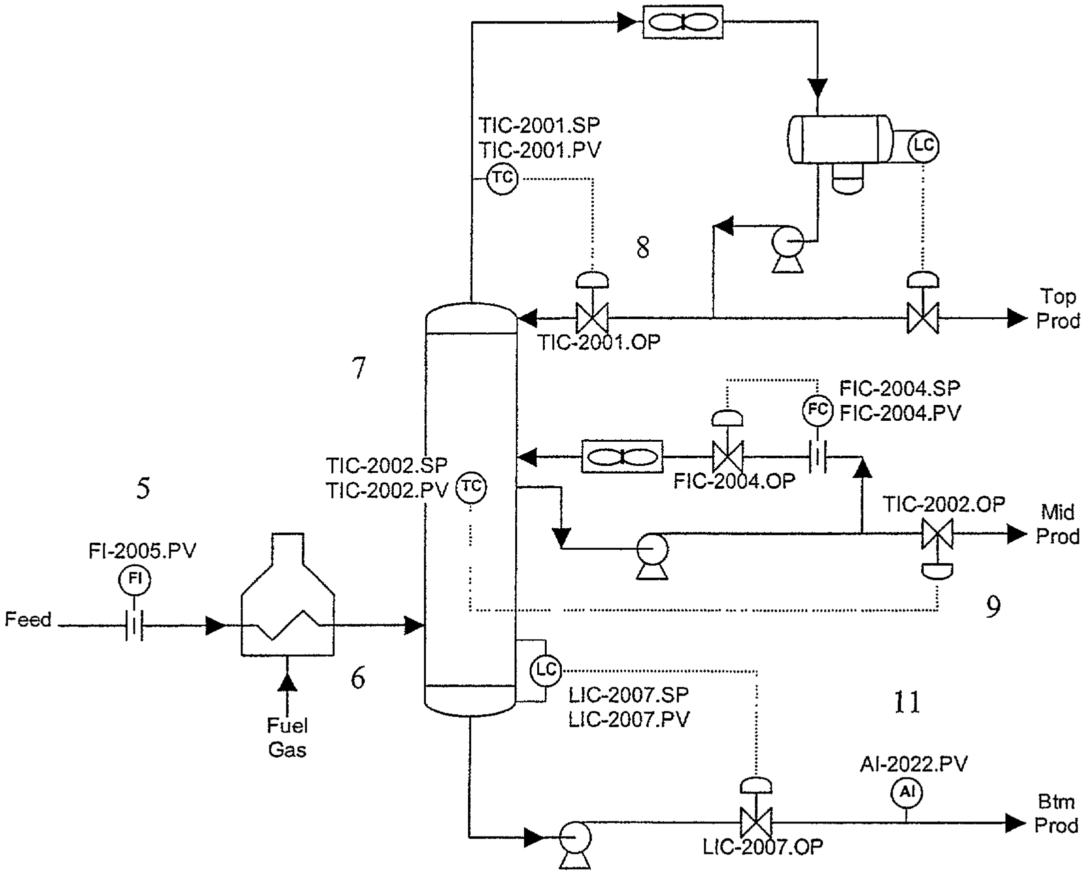

Figure 1: Complex Fractionator Schematic

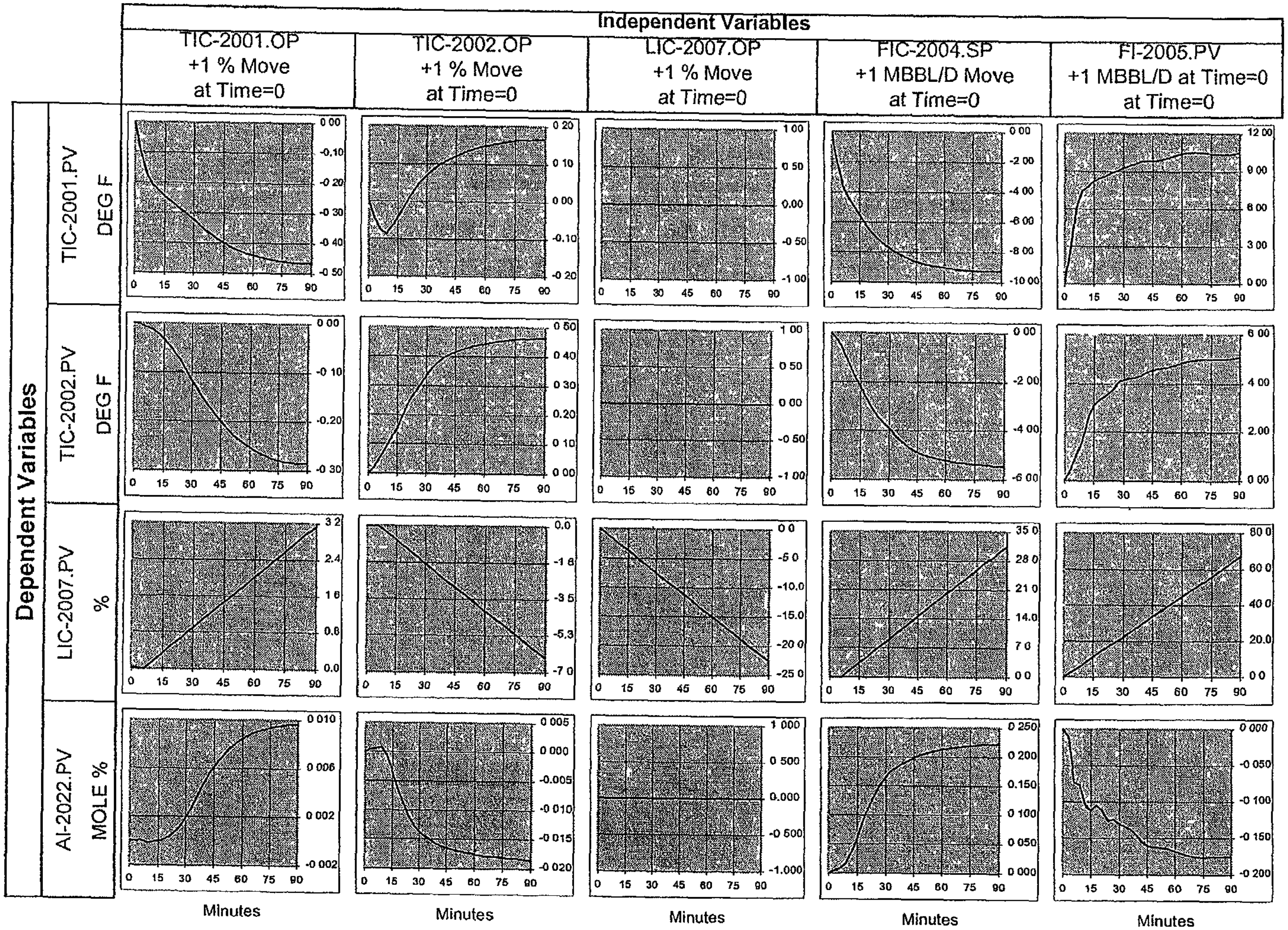

FIG. 2 Fractionator Simulation Based on Valve Position

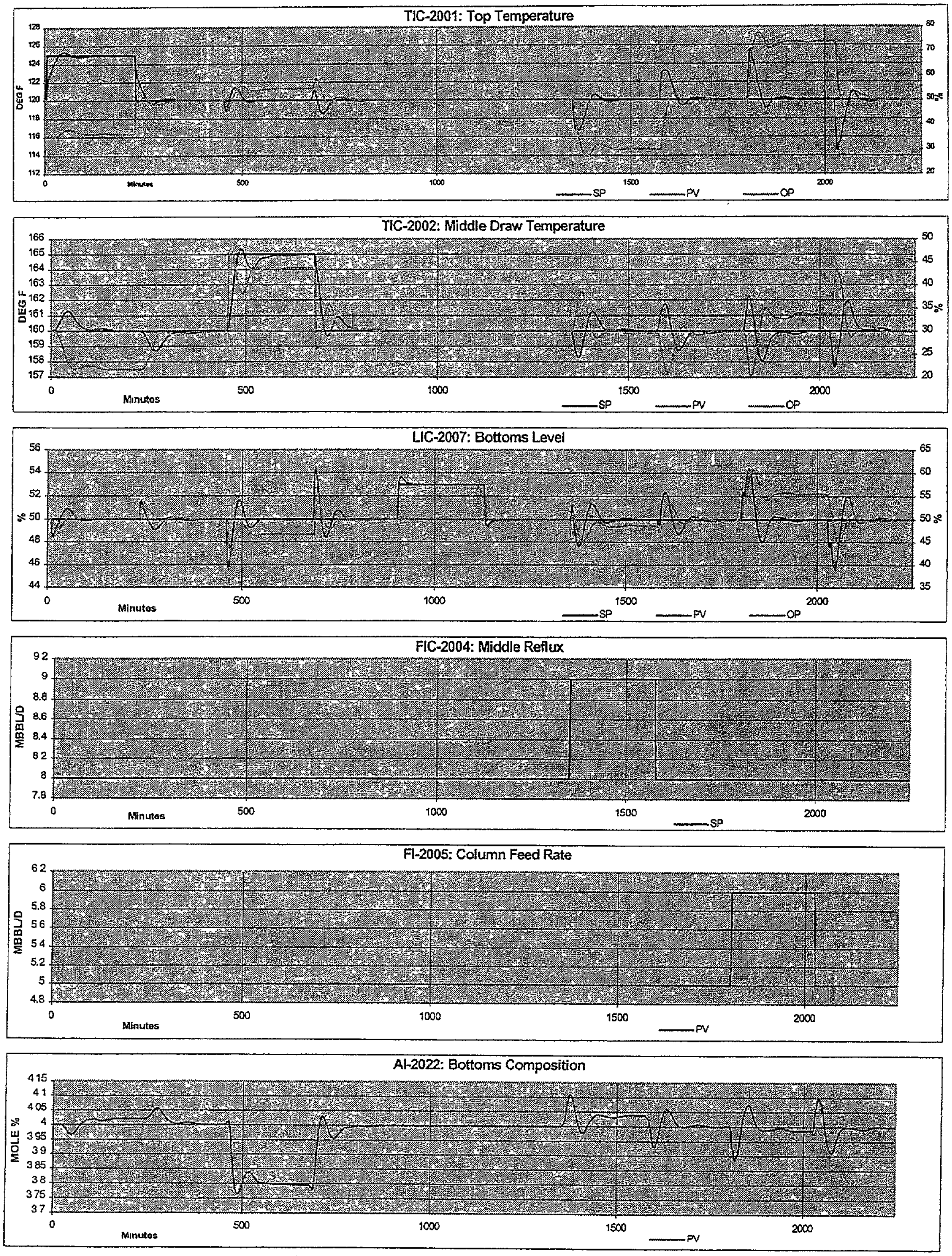

FIG. 13 Column Simulation Plant Test

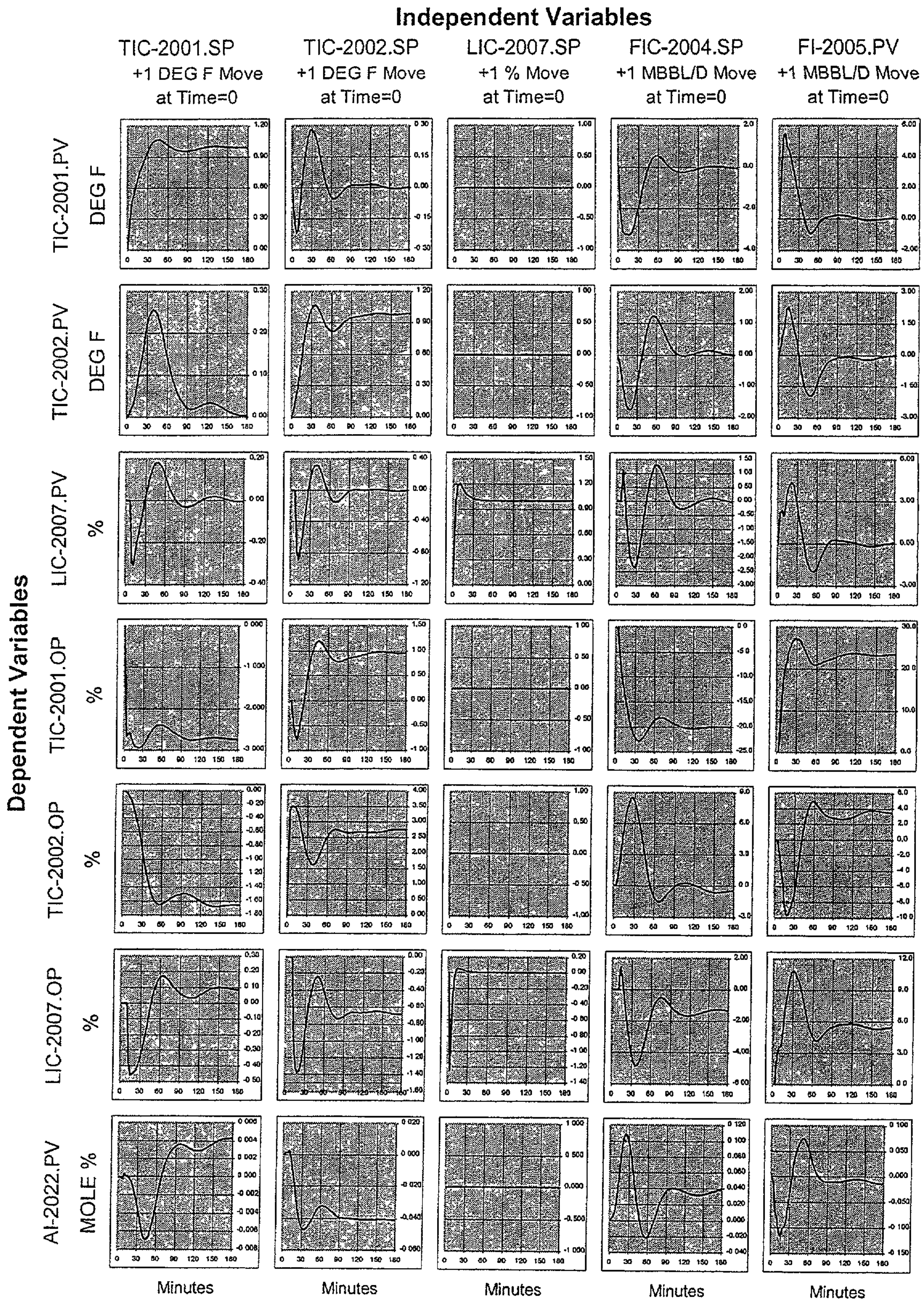

FIG. ~~5~~ 4 Fractionator Model with PID Controllers

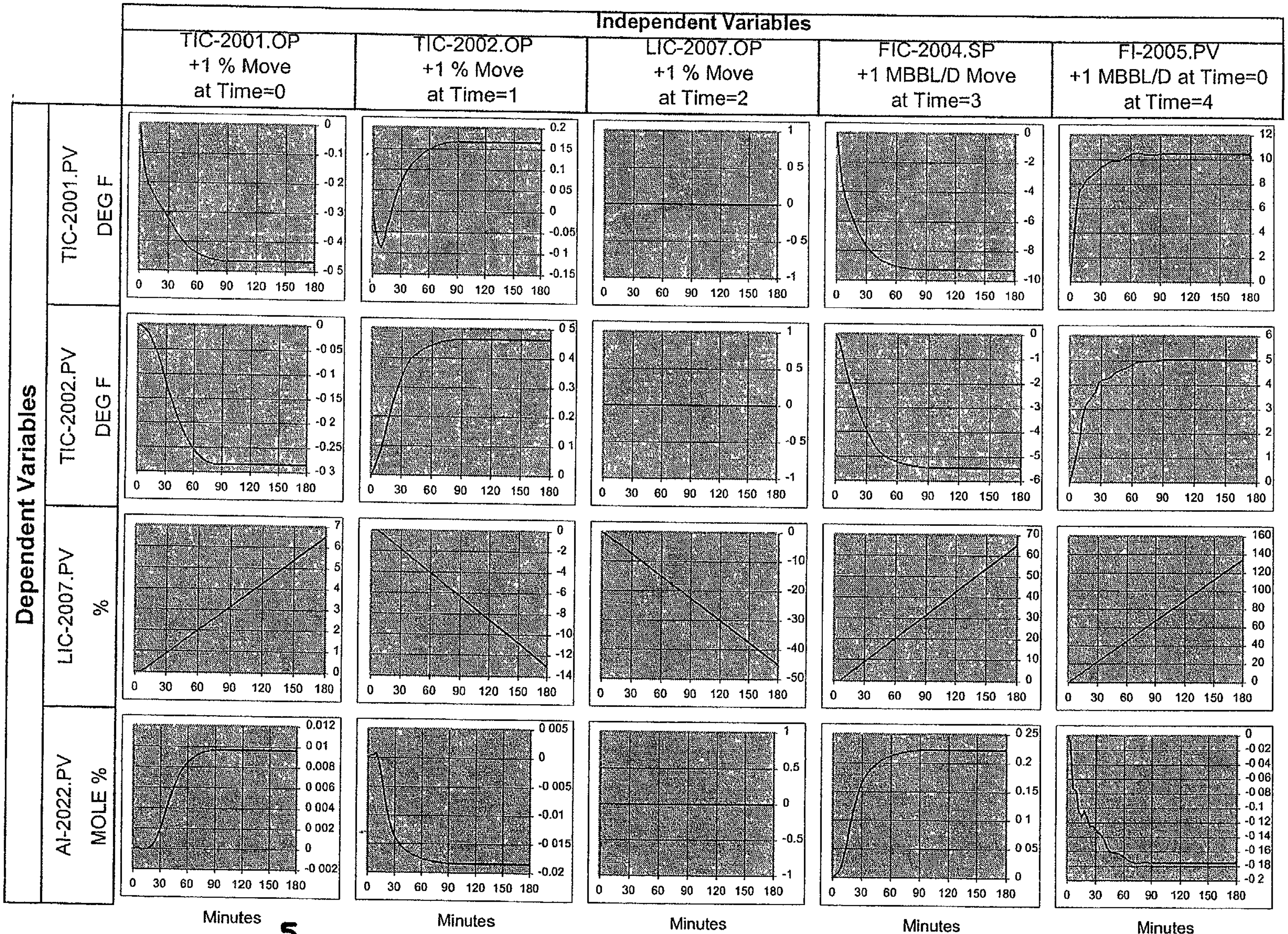

FIG. 5 Original and Recovered Valve Based Models for Fractionator